A GIS STUDY OF BREEDING BIRD HABITATS IN THE FLEMISH COASTAL DUNES AND ITS IMPLICATIONS FOR NATURE MANAGEMENT

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ABSTRACT

In 1997–98 an area of approximately 1300ha of Flemish coastal dunes was censused for breeding birds. Territory maps were drawn and compared with maps on vegetation, hydrology and recreation pressure by the overlay method in a GIS. Twinspan recognized seven breeding bird communities; a DCA-ordination revealed the dominant importance of vegetation succession and the degree of urbanization for breeding bird community variance. Breeding habitats are characterized for all territorial songbirds. The comparison of the distribution of potential habitat and actually occupied habitat stresses the importance of increase of the groundwater level and recreation pressure for specific species. At the landscape level a positive relationship between area of shrub and grey dunes and species number was detected; an opposite relationship exists between area and total territory density.

Introduction

In recent decades the Flemish coastal dune area has suffered significant degradation from urbanization, mass recreation, water collection and scrub encroachment (Provoost and Hoffmann, 1996). To conserve the specific flora and fauna of mesophytic dune grassland and wet dune slacks, the Flemish Community invested in scrub removal and introduction of domesticated grazers. Simultaneously, a monitoring programme was started to investigate the effects of these nature management measures on flora, vegetation, fauna and soil (Bonte et al., 1998). One of the major aims is to study the effects of landscape changes due to human impact (nature management, recreation, urbanization) on the breeding bird fauna. The application of a Geographical Information System (GIS) enables us to model specific habitat or

landscape structure characteristics of breeding bird species. Once modelled, the GIS approach enables us to make predictions of changes in the breeding bird composition in relation to the above-mentioned landscape changes.

Materials and Methods

Breeding birds were censused in the Flemish coastal dunes in 1997 and 1998. The dune areas involved are the Dunes du Perroquet (Bray-Dunes, France), the Westhoek and Houtsaegerduinen (De Panne, Belgium), the Noordduinen, the Doornpanne and Ter Yde (Koksijde, Belgium) and the Ijzermonding (Nieuwpoort, Belgium). We used the territory mapping method described by Hustings et al. (1985) as it is the only effective way to obtain detailed information about breeding bird numbers and territory distribution in the area. The only disadvantage of this method is its time-consuming nature during the inventory period.

During each breeding season (March to July), we visited the dune areas about 10 times. In two years we censused an approximate area of 1300ha of coastal dunes in detail. The interpretation criteria of Hustings et al. (1985) were used to construct the specific territory maps. These maps were digitized with the GIS software package Genamap 6.2. A 1ha grid was used to analyse breeding bird community composition. All grid cells not entirely covered by a censused area (predominantly border cells) were excluded from the analysis. All of the remaining 965ha were included and for these squares the number of territories per breeding bird species was calculated. Overlays were made with maps of present-day vegetation, hydrology and recreation pressure. Twinspan (Hill, 1979a) and Detrended Correspondence Analysis (DCA) (Hill, 1979b) were used for analysis of community composition and ecology.

Results

Breeding bird communities

Seventy-two breeding bird species were recorded in the surveyed area of coastal dunes (see Table 1). Twinspan analysis of the 700 1ha samples revealed seven main bird communities. We named them after the most characteristic bird species: the dunnock–collared dove type, the woodpigeon–blackcap type, the nightingale–turtle dove type, the whitethroat–willow warbler type, the house sparrow–black redstart type, the linnet–partridge type and the little ringed plover–crested lark type. Mean density per hectare of the species per community is listed in Table 1. DCA-ordination of the breeding bird communities is given in Figure 1, the individual species in Figure 2. The first DCA-axis has an eigenvalue of 0.571 and represents a vegetation density gradient from open, bare dune towards dune woodland. The second axis (eigenvalue 0.412) is significantly correlated with the degree of urbanization of the 1ha grid samples.

Table 1. Species list with densities per hectare grid square in the Twinspan end groups (e = excluded from the analysis; ? = no absolute density data). Red List status: 1 = critically endangered; 2 = endangered; 3 = vulnerable; Z = rare; D = declining; N = not on Red List; ? = insufficiently known.

Key to Twinspan end groups: 000 dunnock–collared dove type, 0010 woodpigeon–blackcap type, 0011 nightingale–turtle dove type, 010 whitethroat–willow warbler type, 011 house sparrow–black redstart type, 10 linnet–partridge type, 11 little ringed plover–crested lark type.

Species	English name	000	0010	0011	010	011	10	11	Red List
		Maximum value for each species is emboldened							
Ardea cinerea	Grey heron	0,000	**0,275**	0,000	0,000	0,000	0,000	0,000	N
Tadorna tadorna	Shelduck	0,000	0,025	0,012	0,043	0,052	**0,072**	0,000	N
Anas platyrhynchos	Mallard	0,000	**0,066**	0,006	0,007	0,000	0,028	0,000	N
Accipter nisus	Sparrow hawk	0,000	**0,025**	0,003	0,000	0,000	0,000	0,000	N
Buteo buteo	Buzzard	0,000	**0,008**	0,000	0,000	0,000	0,000	0,000	N
Falco tinnunculus	Kestrel	0,000	**0,016**	0,000	0,000	0,000	0,000	0,000	N
Falco subbuteo	Hobby	0,000	**0,016**	0,000	0,000	0,000	0,000	0,000	N
Perdix perdix	Partridge	0,000	0,000	0,003	0,102	0,102	**0,347**	0,000	3
Phasianus colchicus	Pheasant	0,000	0,216	**0,332**	0,284	0,105	0,072	0,000	N
Rallus aquaticus	Water rail	0,000	0,000	**0,006**	0,000	0,000	0,000	0,000	?
Gallinula chloropus	Moorhen	0,000	**0,075**	0,000	0,000	0,000	0,000	0,000	N
Haematopus ostralegus	Oystercatcher	0,000	0,000	0,000	0,000	0,000	**0,028**	0,000	N
Charadrius dubius	Little ringed plover	0,000	0,000	0,000	0,017	0,000	0,050	**0,482**	N
Charadrius alexandrinus	Kentish plover	0,000	0,000	0,000	0,000	0,000	0,000	**0,003**	1
Vanellus vanellus	Lapwing	0,000	0,000	0,000	0,000	0,000	**0,028**	0,017	N
Columba oenas	Stock dove	0,000	0,050	0,003	0,007	**0,157**	0,014	0,000	N
Columba palumbus	Woodpigeon	1,235	**1,266**	0,963	0,169	0,000	0,014	0,000	N
Streptopelia decaocto	Collared dove	**1,352**	0,225	0,018	0,015	0,210	0,014	0,000	N
Streptopelia turtur	Turtle dove	0,000	0,083	**0,470**	0,128	0,052	0,014	0,000	D
Merops apiaster	Bee-eater	e	e	e	e	e	e	e	?
Cuculus canorus	Cuckoo	0,058	0,225	**0,381**	0,343	0,052	0,246	0,068	N
Athene noctua	Little owl	0,000	0,000	0,000	**0,002**	0,000	0,000	0,000	N
Asio otus	Long-eared owl	?	?	?	?	?	?	?	N
Picus viridis	Green woodpecker	0,058	0,241	**0,480**	0,302	0,000	0,043	0,034	N
Dendrocopus major	Great spotted woodpecker	0,000	**0,300**	0,107	0,002	0,000	0,000	0,000	N
Dendrocopus minor	Lesser spotted woodpecker	0,000	**0,016**	0,000	0,000	0,000	0,000	0,000	N
Galerida cristata	Crested lark	0,000	0,000	0,000	0,017	0,315	0,115	**0,655**	1
Alauda arvensis	Skylark	0,000	0,000	0,000	0,015	0,000	**0,087**	0,000	D
Anthus pratensis	Meadow pipit	0,000	0,008	0,006	0,146	0,052	**1,275**	0,586	D
Troglodytes troglodytes	Wren	0,411	**1,216**	0,572	0,058	0,000	0,028	0,000	N
Prunella modularis	Dunnock	**1,117**	0,241	0,418	0,584	0,526	0,144	0,000	N
Erithacus rubecula	Robin	0,000	**0,375**	0,055	0,002	0,000	0,000	0,000	N
Luscinia megarhynchos	Nightingale	0,058	0,141	**0,895**	0,317	0,000	0,000	0,000	3

Species	English name	000	0010	0011	010	011	10	11	Red List
Phoenicurus ochruros	Black redstart	0,647	0,030	0,015	0,023	**0,789**	0,028	0,137	N
Phoenicurus phoenicurus	Redstart	**0,176**	0,141	0,073	0,007	0,000	0,000	0,000	3
Saxicola torquata	Stonechat	0,000	0,008	0,030	0,246	0,157	**0,318**	0,068	2
Oenanthe oenanthe	Wheatear	0,000	0,000	0,000	0,033	0,052	**0,449**	0,000	1
Turdus merula	Blackbird	**1,235**	0,833	0,689	0,335	0,421	0,028	0,068	N
Turdus philomelos	Song thrush	**0,235**	0,191	0,049	0,038	0,000	0,000	0,000	N
Turdus viscivorus	Mistle thrush	**0,176**	0,083	0,080	0,100	0,052	0,000	0,000	N
Cettia cetti	Cetti's warbler	0,000	0,016	**0,043**	0,010	0,000	0,000	0,000	Z
Locustella naevia	Grasshopper warbler	0,000	0,000	0,135	**0,171**	0,000	0,000	0,000	3
Acrocephalus palustris	Marsh warbler	0,000	0,000	0,033	**0,035**	0,000	0,014	0,000	N
Hippolais icterna	Icterine warbler	0,000	0,033	**0,523**	0,015	0,000	0,000	0,000	N
Hippolais polyglotta	Melodious warbler	0,000	0,000	**0,003**	0,000	0,000	0,000	0,000	N
Sylvia curruca	Lesser whitethroat	0,058	0,075	**0,292**	0,158	0,000	0,057	0,000	N
Sylvia communis	Whitethroat	0,000	0,100	0,870	**0,928**	0,000	0,057	0,034	N
Sylvia borin	Garden warbler	0,000	0,075	**0,283**	0,061	0,000	0,000	0,000	N
Sylvia atricapilla	Blackcap	0,000	**1,091**	0,630	0,030	0,000	0,000	0,000	N
Phylloscopus collybita	Chiffchaff	0,294	**0,925**	0,790	0,069	0,000	0,000	0,000	N
Phylloscopus trochilus	Willow warbler	0,000	0,033	**0,883**	0,697	0,105	0,000	0,000	N
Regulus regulus	Goldcrest	0,000	**0,033**	0,006	0,000	0,000	0,000	0,000	N
Aegithalos caudatus	Long-tailed tit	0,059	0,058	**0,172**	0,033	0,000	0,000	0,000	N
Parus cristatus	Crested tit	0,000	0,000	**0,006**	0,000	0,000	0,000	0,000	N
Parus caeruleus	Blue tit	**0,235**	0,183	0,224	0,020	0,000	0,000	0,000	N
Parus major	Great tit	**0,529**	0,416	0,486	0,048	0,000	0,000	0,000	N
Sitta europaea	Nuthatch	0,000	**0,016**	0,000	0,000	0,000	0,000	0,000	N
Certhia brachydactyla	Short-toed treecreeper	0,000	**0,283**	0,036	0,000	0,000	0,000	0,000	3
Oriolus oriolus	Golden oriole	0,000	**0,291**	0,056	0,002	0,000	0,000	0,000	N
Garrulus glandarius	Jay	0,000	0,091	**0,095**	0,020	0,000	0,000	0,000	N
Pica pica	Magpie	**0,235**	0,208	0,169	0,053	0,052	0,014	0,000	N
Corvus monedula	Jackdaw	0,000	0,008	0,000	0,005	**0,210**	0,000	0,000	N
Corvus corone	Carrion crow	0,000	**0,183**	0,055	0,013	0,000	0,000	0,000	N
Sturnus vulgaris	Starling	0,000	0,000	0,003	0,000	**0,105**	0,014	0,000	D
Passer domesticus	House sparrow	**1,823**	0,108	0,021	0,020	1,421	0,072	0,000	D
Passer montanus	Tree sparrow	0,000	0,000	**0,015**	0,005	0,000	0,000	0,000	D
Fringilla coelebs	Chaffinch	0,000	**0,066**	0,012	0,000	0,000	0,000	0,000	N
Serinus serinus	Serin	**0,059**	0,000	0,000	0,000	0,000	0,000	0,000	?
Chloris chloris	Greenfinch	e	e	e	e	e	e	e	N
Carduelis carduelis	Goldfinch	e	e	e	e	e	e	e	N
Carduelis spinus	Siskin	0,000	**0,025**	0,005	0,000	0,000	0,000	0,000	Z
Carduelis cannabina	Linnet	0,058	0,025	0,375	0,054	0,315	**0,739**	0,137	N
Carduelis flammea	Redpoll	0,000	0,000	**0,040**	0,000	0,000	0,000	0,000	Z
Pyrrhula pyrrhula	Bullfinch	0,000	**0,025**	0,012	0,000	0,000	0,000	0,000	N
Emberiza schoeniclus	Reed bunting	0,000	0,000	0,012	**0,066**	0,000	0,000	0,000	D

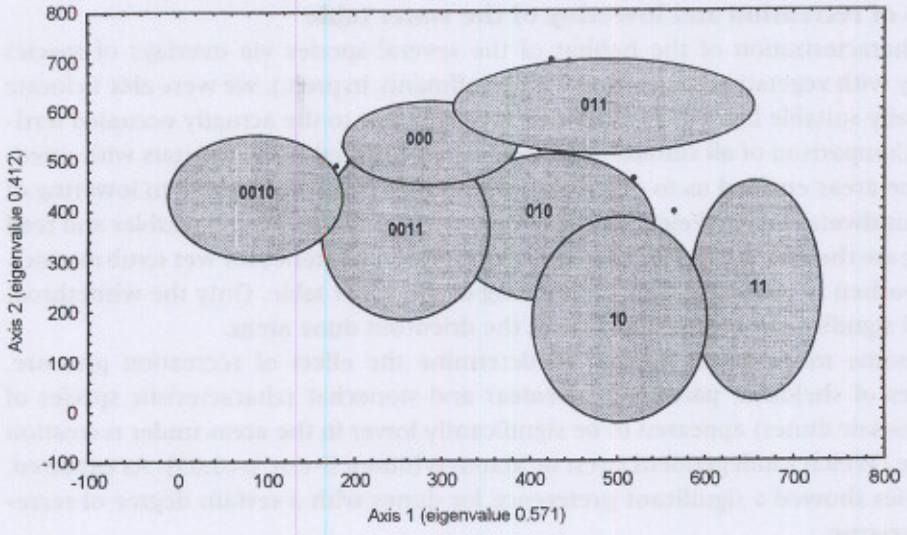


Figure 1. *DCA-plot of the breeding bird communities based on species composition in 1ha grid squares. Approximate areas of the Twinspan end groups on the DCA-plot are shown.*

Key to Twinspan end groups:

000 Dunnock–collared dove type
0010 Woodpigeon–blackcap type
0011 Nightingale–turtle dove type
010 Whitethroat–willow warbler type
011 House sparrow–black redstart type
10 Linnet–partridge type
11 Little ringed plover–crested lark type

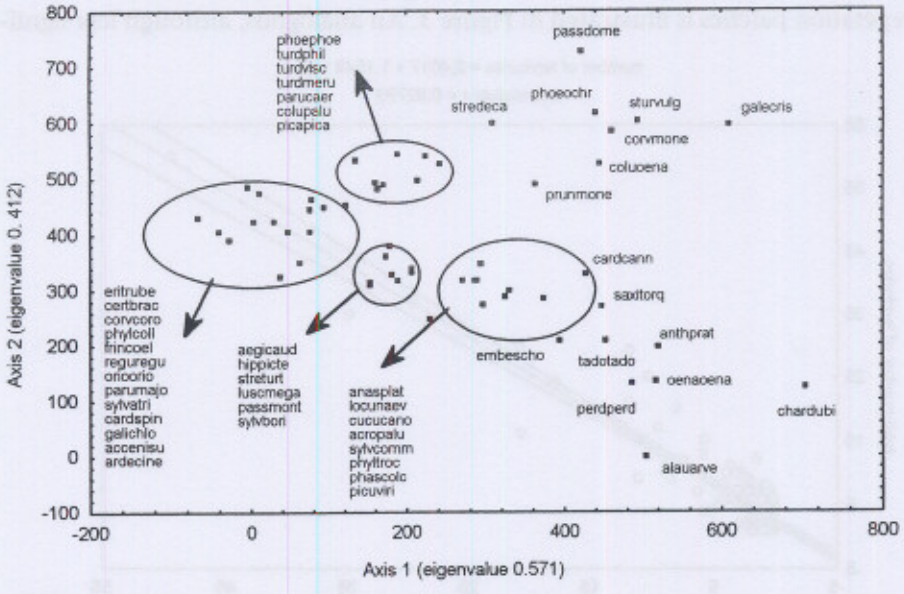


Figure 2. *DCA-plot of the breeding bird species based on species composition in 1ha grid squares. Bird species are labelled by an abbreviation of the species names listed in Table 1, four letters for the genus and four for the species.*

Effects of recreation and lowering of the water table

After characterization of the habitat of the several species via overlays of species territory with vegetation maps (Bonte and Hoffmann, in prep.), we were able to locate potentially suitable habitats in the study area adjacent to the actually occupied territories. Comparison of all suitable hydrologically unaltered (wet) habitats with dried-out dune areas enabled us to determine which species are vulnerable to lowering of the groundwater table (Welch's independent t-test, $p<0.05$). Marsh warbler and reed bunting are the only species which show a significant preference for wet scrub mosaics. The moorhen is also vulnerable to lowering of the water table. Only the whitethroat reached significantly higher densities in the dried-out dune areas.

The same method was applied to determine the effect of recreation pressure. Densities of shelduck, partridge, wheatear and stonechat (characteristic species of open, mosaic dunes) appeared to be significantly lower in the areas under recreation pressure (Welch's independent t-test or Mann-Whitney U-test, $p<0.05$). As expected, no species showed a significant preference for dunes with a certain degree of recreation pressure.

The relation between scrub size and breeding bird numbers and densities

Superimposition of the vegetation map with all territory maps allows the detection of landscape-ecological relationships between the size of homogeneous vegetation patches and territory density and total number of breeding birds.

The positive relationship between total breeding bird numbers and the size of mixed scrub vegetation patches is illustrated in Figure 3. An analogous, although less signif-

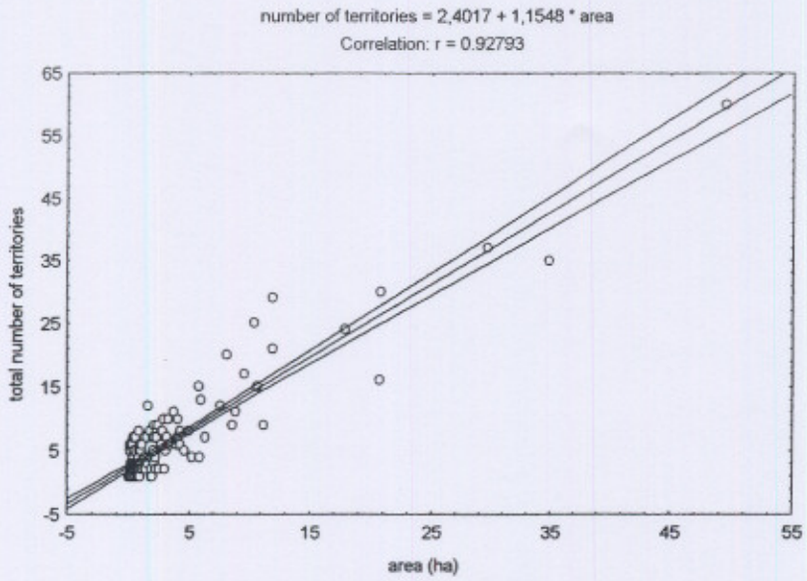


Figure 3. *The relationship between mixed scrub patch size (hectares) and the total number of bird territories.*

icant relationship exists for breeding birds of grey dunes and their characteristic dune habitat (see Fig. 4).

Total bird density–area relationships are characterized by a clear tendency towards density decrease with increasing size of scrub or grey dune vegetation patch (see Figs. 5 and 6). After a natural logarithm transformation of the data this significant negative relationship is clearly demonstrated (see Fig. 7). Despite this general negative relationship, specific species density–patch area relationships reach a maximum at differing, not necessarily small, patch sizes. Figures 8 and 9 illustrate this relationship for the turtle dove and the lesser whitethroat in mixed scrub.

Discussion and Implications for Flemish Dune Management

Although the Flemish coastal dunes have already been subject to a lot of ornithological research, specific habitat characteristics of breeding birds had not previously been studied. Despite much detailed research on breeding bird communities (Bibby et al., 1989; Fuller et al., 1989; Gillings et al., 1998; Smith et al., 1992 [woodlands]; Lysaght, 1989 [agricultural landscape] and Stillman and Brown, 1994 [upland vegetation]), no analogous studies are available of dune breeding birds. Only Lust et al. (1995) investigated the relationship between vegetation and total bird densities in the dune area of the eastern Flemish coast. For the western Flemish coast (Bonte, 1994) and for the dune area between Katwijk and Scheveningen (Netherlands) (Van der Meer, 1996) only general breeding bird inventories are known.

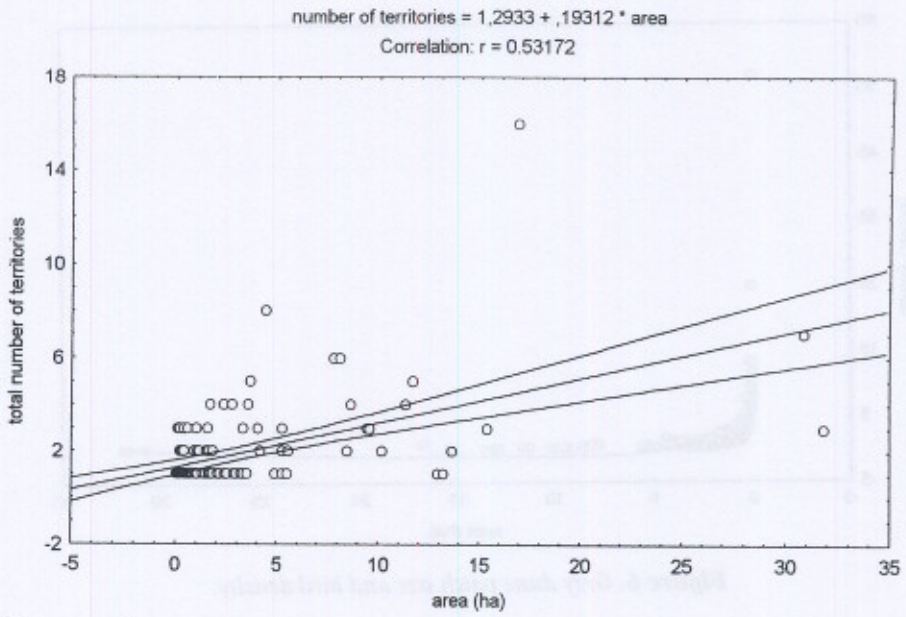
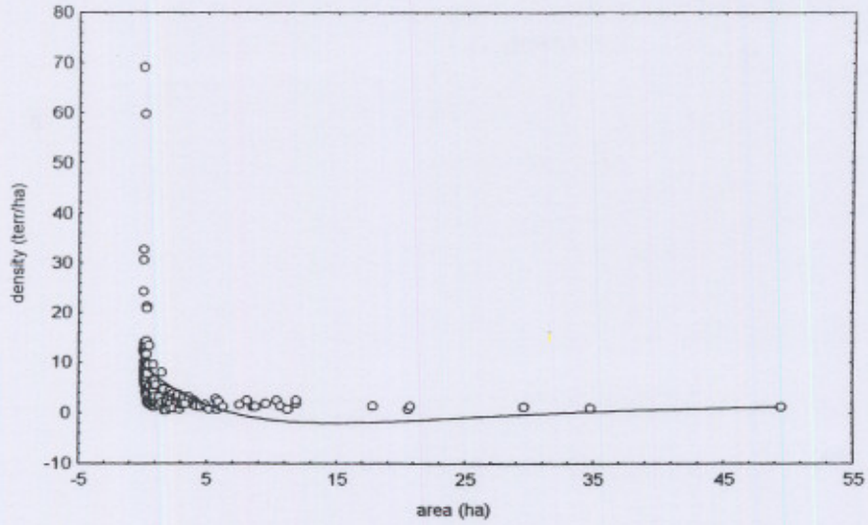


Figure 4. *The relationship between grey dune patch size (hectares) and the total number of bird territories.*



Figures 5–7. *The relationship between vegetation patch area (hectares) and density of breeding bird territories (number of territories per hectare).*
Figure 5. Hippophae-Sambucus *patch size and bird density.*

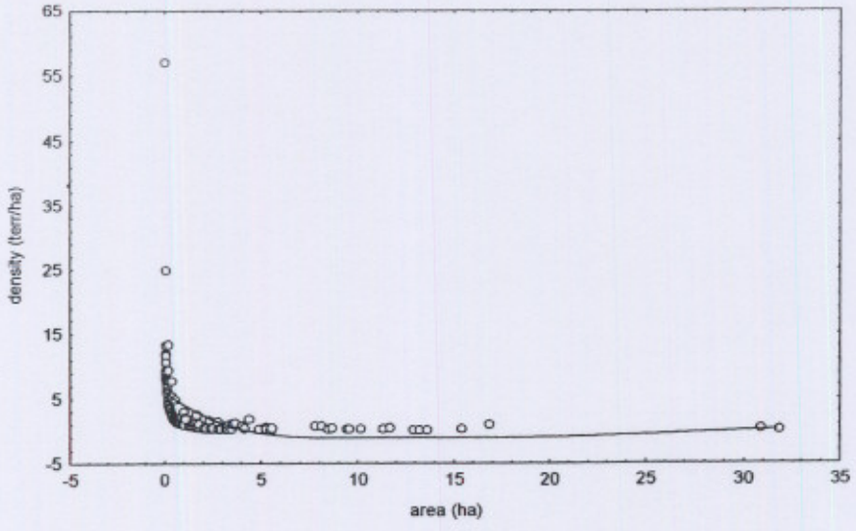


Figure 6. *Grey dune patch size and bird density.*

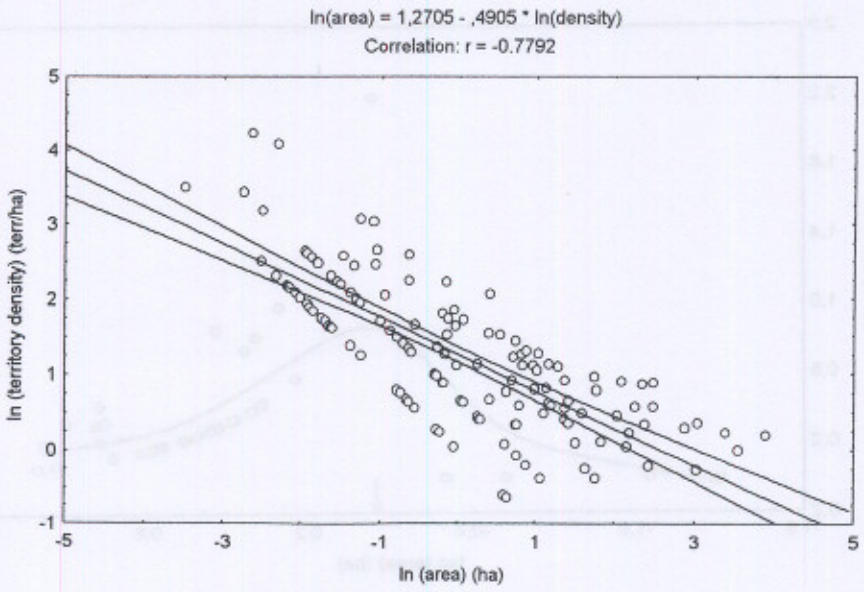


***Figure 7**. Scrub patch size and bird density natural logarithm transformation.*

In general, the main determining parameters for bird communities are hydrology, scrub and woodland proportion or altitude. The breeding bird communities in the Flemish coastal dunes are determined by the same parameters, of which vegetation succession appears to be the most important. Flemish Red-List (Devos and Anselin, in prep.) species in the coastal dune area are characteristic of open, sandy or short, grazed vegetation, scrub mosaic and (less important) woody scrub vegetation and dune woodland. Species of grey dunes and short grazed grasslands in mosaic with low scrubs are especially threatened in Flanders. Taking into consideration the vulnerability of these specific species to recreation pressure, conservation of this habitat should be one of the main aims of the present management.

The area–species number relationship of scrub species emphasizes the importance of large vegetation patches for conservation and enhancement of the total number of breeding birds. Although total numbers increase with patch size, territory density is strongly negatively correlated with the patch size. This can be explained by the species-specific optimal scrub patch sizes: even typical scrub species do not increase their density with increasing scrub patch size, but reach their maximum density at relatively small patch sizes. As a consequence total territory density would increase with an increase of the area of scrub vegetation in mosaic with other vegetation types (for example short grassland, woodland).

Together with abiotic (altitude, climate) and biotic (competition, predation, nutrition) parameters, vegetation patch size is an important (but overlooked) characteristic that can explain superficially large differences (see Lust et al., 1995) in

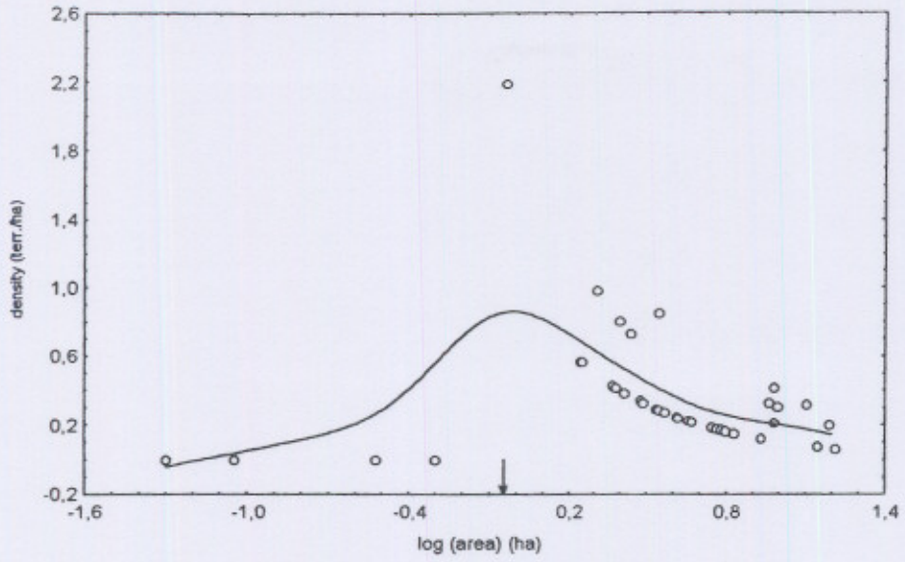


Figure 8. *Relationship between mixed scrub patch area (hectares) and turtle dove territory density (number of territories per hectare).* ↓ *indicates optimal patch size.*

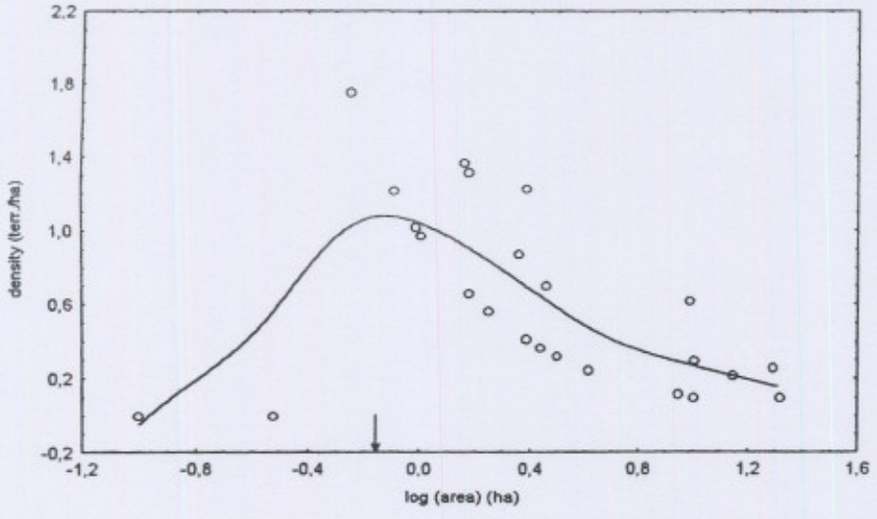


Figure 9. *Relationship between mixed scrub patch area (hectares) and lesser whitethroat territory density (number of territories per hectare).* ↓ *indicates optimal patch size.*

breeding bird densities between analogous scrub types in different study areas.

Since the main goal of contemporary nature management is the optimization of biological (including avian) diversity, grazing at low herd density should be encouraged in the Flemish coastal dunes. It is probably the only management tool that can effectively increase the area of short grassland, in fine- to large-scale mosaics with scrub and dune woodland. In this way a lot of extra suitable habitat can be generated for Red-List species, while common scrub species can reach higher densities in the remaining small scrub patches.

At present domesticated livestock (Highland cattle, donkeys, Shetland ponies and Konik horses) graze approximately 220ha of the dune area. Since annual monitoring of all breeding bird species in the managed dune areas would be too time consuming, a selection should be made of typical species from the identified breeding bird communities. Since all communities have typical Red-List species, detailed monitoring of these should reveal important data on the effect of landscape changes due to nature management or natural succession on individual breeding birds and on breeding bird communities.

Acknowledgments

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